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RESEARCH SUMMARY

forest sciences
NELSON FOREST REGION

October 1995 RS-021

Management Options for *Armillaria* Root Disease

■ **Appropriate treatment choices are critical for Armillaria Root Disease management**

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INTRODUCTION

Armillaria ostoyae is a component of most forest ecosystems – managed or natural – in the southern third of British Columbia. On some sites, host trees show signs and symptoms of the root disease caused by this fungus; however, on others, trees may be infected but show no symptoms. The effects this root disease can have on forests should be considered during the preparation of any forest management prescription. This will reduce the chances of forestry activities inadvertently increasing the incidence and severity of *Armillaria ostoyae* on a site.

EXTENT IN NATURAL STANDS

Armillaria ostoyae occurs at endemic levels in most undisturbed forests within its geographic range (see RS-015). *Armillaria ostoyae* and its hosts often reach an equilibrium between the pathogenicity of the fungus and the resistance of the host. In these cases, the fungus does not kill the tree, and the tree cannot eliminate the fungus (10). However, this balance may be upset in favour of the fungus by stresses such as drought, insect attack and other diseases, and by management practices that create stumps.

EXTENT IN MANAGED STANDS

In logged areas, either planted or naturally regenerated, symptoms of *Armillaria* root disease are common. Stands that have been partially cut often have higher incidences of *Armillaria ostoyae* infection. On partially logged sites, the stumps provide a food base for *Armillaria ostoyae*, and the residual trees provide opportunities for spread via root-to-root contacts.

Armillaria ostoyae is also a common problem in clearcut areas. Root contacts between the new generation of trees are limited for the first decade or so but increase through the second and third decades. Therefore, initial spread of *Armillaria* is from colonized stumps to seedlings planted nearby. As time passes, root contacts increase and the inoculum present in stumps becomes depleted, and it is these infected seedlings/saplings that transmit *Armillaria* to adjacent healthy trees.

In coastal forests, mortality caused by *Armillaria ostoyae* usually ceases by age 25. In interior British Columbia forests mortality occurs throughout the rotation (13). The amount of disease in individual stands will depend on species composition, amount of inoculum, past management activities, and site conditions (7). Root disease mortality of highly susceptible species will be chronic throughout the life of the stand. In stands dominated by western redcedar and western hemlock, mortality resulting from root disease may decrease after age 20 (7).

Armillaria ostoyae will undoubtedly affect the vigour, stocking levels and species composition of second-growth stands. Ministry of Forests Silviculture Branch is currently compiling statistics from the ISIS database on *Armillaria* extent in second-growth stands for the Nelson Forest Region. They have found that of the openings harvested from 1990 to present, 19 % of the area is infected with *Armillaria* (50,100 hectares of 269,623 hectares). A detailed report will be available in the near future.

MANAGEMENT OPTIONS

The choice of strategies for managing *Armillaria ostoyae* at the stand level is made more easily in the context of landscape level plan-

ning. The biology of *Armillaria ostoyae*, amount of disease, ecology of the site, and land use objectives must be considered. Managing areas with high visual or wildlife values, for example, may require a very different strategy (e.g., no treatment) from managing for timber production.

Management options for *Armillaria ostoyae* may be applied either during the harvest phase, or post-harvest through choice of silvicultural practices. It is not the intent of this summary to indicate that one option is a better choice than another. Each may be appropriate in certain circumstances and it is up to the land manager to weigh the relative advantages and disadvantages of each.

Harvest phase

1. Stump removal

The reduction of *Armillaria ostoyae* inoculum on a site may be achieved through the removal of stumps. The rationale for this practice is that by removing the source of fungal inoculum from the site, the incidence of root disease in the next rotation should be reduced.

Stump removal can be done in conjunction with either

Pushover logging

clearcutting or partial cutting prescriptions. The stumps can be removed either during the falling phase using an excavator or feller buncher to push over the trees with root systems attached (pushover logging), or, following falling using an excavator to dislodge stumps from the ground (stumping). Costs of pushover felling appear to be about 15% greater than conventional operations (3).

Potential disadvantages of this treatment could include the possibility of excessive site disturbance, and the reduction in soil organic matter and nutrients (2). The practise is restricted due to slope and soil conditions, and research is currently under way to begin quantifying these possible detrimental side effects of stumping.

Post-harvest - New stands

1.Regenerating to less-susceptible species and mixtures

Species with low susceptibility to infection should be considered when regenerating sites infested with *Armillaria ostoyae* (see Table 1). These species should be favoured over other species, assuming they are ecologically suited to the site. However, species susceptibility to *Armillaria* root disease appears to vary to some extent depending on ecosystem (8),

Table 1: Species susceptibility to mortality

Species	Susceptibility			
	High	Moderate	Low	Resistant
Douglas-fir	■			
Abies spp.	■			
Spruce	■			
Lodgepole pine		■		
Hemlock		■		
Cedar		■		
Ponderosa pine			■	
Larch			■	
Birch (young trees)				■

site productivity, and tree age. More research on individual species susceptibility to the disease on a range of site conditions, treatment regimes, and age ranges is needed (19).

Coniferous species found in southeastern British Columbia show little resistance to *Armillaria ostoyae* until they are 15-20 years old. Therefore, infected plantations will likely suffer some mortality from root disease regardless of species choice. However, if less-susceptible species are planted, long-term losses from plantations should be reduced. Establishing plantations with a mixture of species (conifers and deciduous) may also help reduce mortality due to root disease. Different species exhibit different rooting habits, and mixed species plantings may decrease root-to-root contacts as seedlings grow, thus reducing disease incidence (19).

2. Fallow

This involves seeding a site with grasses or legumes to eliminate available hosts for *Armillaria ostoyae*. Existing food bases (stumps) for the fungus will eventually be depleted and inoculum will disappear. At that time, the site can be reforested with species susceptible to *Armillaria* that could not otherwise be planted on the site. The disadvantage of this treatment is that a site may lie fallow for 10 to 20 years before inoculum disappears. This option would provide opportunity for grazing and foraging for livestock and wildlife, but it has not been used operationally in British Columbia.

3. Biological control

Biological control of *Armillaria* root disease is currently

being studied as an alternative control option. Advantages over mechanical control methods include the retention of coarse woody debris, reduced risk of soil disturbance, and applicability under a wider range of site conditions (20). Researchers in British Columbia are currently working on inoculation of *Armillaria ostoyae* infected stumps with competitive fungi (B. Chapman, pers comm., 1995). Similar research has been completed with some success in Australia (16). These treatments are still experimental and under development and are not used operationally in British Columbia.

4. Chemical control

Fumigants such as chloropicrin, methyl bromide, carbon disulfide, Vapam, or Vorlex have been effective in eliminating *Armillaria ostoyae* in small infected stumps (5). However, use of fungicides to protect living trees from underground infection has been shown to be ineffective (6). Detrimental effects of these chemicals on non-target organisms are being tested in the Pacific Northwest of the United States. Chemical control methods have not been used operationally in British Columbia.

5. Variable planting distributions

It has been suggested that planting seedlings away from infected stumps may reduce chances of root contact with inoculum. In a 10-year-old plantation, Woods (19) found that reducing the distance between a tree and a colonized stump increased the probability that the tree would be infected. However, he found that this relationship did not hold for a 25-year-old plantation. A brushing treatment completed on the 25-year-old plantation re-activated and spread the *Armillaria ostoyae* through the freshly cut stumps. Therefore, trees closer to an infected stump (of the original stand) were no more likely to be infected than those trees further away (19).

Stumps are the primary inoculum source for about 10 years after harvesting. Therefore, planting seedlings away from stumps may offer some protection from *Armillaria ostoyae* infection for trees up to 10 years of age, after which tree-to-tree spread is more common. Current guidelines state that any tree within 3 m of an infected crop tree cannot be considered as free to grow. The validity of the 3 m rule depends on age of the plantation and the treatments that have been conducted on the site (19).

Post-harvest - Stand tending

Little research has been done on the effects of *Armillaria ostoyae* on the productivity of older second-growth stands. It is likely however, that current stand tending practices will increase the incidence and damage by *Armillaria ostoyae* in managed stands. Woods (19) reported that timber volumes currently harvested from the highly productive ecosystems of the ICH biogeoclimatic zone would likely not be achieved in the future given present forest management practices such as brushing, juvenile spacing, and partial cutting. These practices can greatly enhance the incidence of *Armillaria* root disease by providing new food bases for the fungus. In order to manage the disease in older second-growth stands, activities that trigger an increase in *Armillaria* incidence must be avoided.

1. No treatment

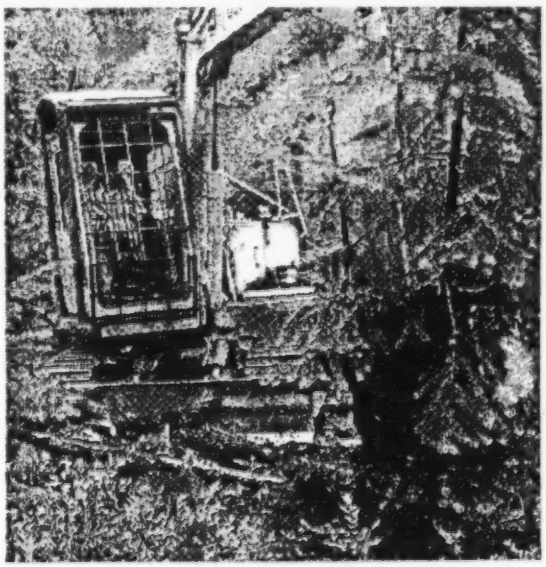
Woods (19) and others have detailed the dramatic impact of stand tending treatments such as brushing and spacing on *Armillaria ostoyae* infection. Woods (19) found significant differences in infection on two similar 1969 Douglas-fir plantations, one unbrushed and one brushed in 1984/86. Only 1.8% of the stems in the unbrushed plantation were dead and infected, compared to 8.5% in the brushed plantation (19). In young stands infected with *Armillaria* root disease, brushing and spacing should be avoided, especially where leave trees are highly susceptible to infection.

2. Favouring species with low susceptibility

Where low-susceptibility species are present, these can be favoured during pre-commercial or commercial thinning; when using advanced regeneration; and in seed tree, shelterwood, or group selection prescriptions (4). This option is only feasible when the disease levels are low.

3. Pop-up spacing

Where spacing is required on sites infected with *Armillaria ostoyae*, pop-up spacing may eliminate the inoculum flush that occurs following conventional spacing. A small feller buncher or excavator with a modified clam shell bucket attachment is used to pull young trees out of the ground with root systems intact (D. Norris, pers. comm., 1995). This potentially removes much of the inoculum source from the soil. Pop-up spacing can reduce root contact between infected and healthy trees. This treatment is being used on a semi-operational basis in British Columbia. Costs have been about $1500-2000/ha, but are



Pop-up spacing

expected to go down with operator experience. As in stump removal, pop-up spacing has the potential of producing soil disturbance. Research is required to quantify this concern.

In some parts of Southeastern B.C., hand-pulling is being used operationally in young lodgepole pine stands as an alternative to mechanized pop-up spacing. A pee-vee like tool is currently being developed to assist with hand-pulling/popping up the young trees.

CONCLUSION

A good understanding of the behaviour and the ecological relationships present on each site is critical to the control of *Armillaria* root disease in managed stands. There are several management options available. When deciding upon a strategy to treat infected sites, the land manager must weigh the relative advantages and disadvantages of each according to site-specific stand conditions. The most appropriate management option for a site must be determined by considering cost, effectiveness, and impacts to other values.

REFERENCES

1. Bloomberg, W.J. and D.J. Morrison. 1989. Relationship of growth reduction in Douglas-fir to infection by *Armillaria* root disease in southeastern British Columbia. Phytopathology 79: 482-487.

2. Davis, G.P. and B. Wells. 1994. Stumping and pushover logging in the Nelson Forest Region 1992 and 1993 soil disturbance surveys. B.C. Min. For., Nelson, B.C.Tech. Rep. TR-009.

3. DeLong, D.L. 1994. Review of five time and motion studies completed on root removal treatments in the Nelson Forest Region. B.C. Min. For., Nelson, B. C. Tech Rep. TR-006.

4. Filip, G.M. and J.T. Hoffman. 1990. Root disease management in western-montane forest soils. U. S. Dept. Agric. For. Serv. Gen. Tech. Rep. INT-280. pp. 167-170.

5. Filip, G.M. and L.F. Roth 1977. Stump injections with soil fumigants to eradicate *Armillaria mellea* from young growth ponderosa pine killed by root rot. Can. J. For. Res. 7(2): 226-231.

6. _____. 1987. Seven chemicals fail to protect ponderosa pine from *Armillaria* root disease in central Washington. U.S.Dept. Agric. For. Serv. Res. Note. PNW-460. 8p.

7. Hagle, S.K. and D.J. Goheen. 1988. Root disease response to stand culture. In: Proceedings of the future forests of the intermountain west: A stand culture symposium. Ogden, UT: U.S. Dept. Agric. For. Serv., Gen. Tech. Rep. INT-243. pp.303-309.

8. Hagle, S.K. and C.G. Shaw III. 1991. Avoiding and reducing losses from Armillaria root disease. In : Shaw, C., III and G.A. Kile. 1991. Armillaria Root Disease. U.S. Dept. Agric. For. Serv. Agric. Handb. No. 691. 233p.

9. Harvey, A.E. 1991. *Armillaria*: a role in long term stability of native, inland western forests. In: Proceedings of the 38th Annual Western International Forest Disease Work Conference. September 1990. Hoffman, J. and L.H. Spiegel (editors). U.S. Dept. Agric. For. Serv. pp.17-21.

10. Hood, I.A., D.B. Redfern and G.A. Kile. 1991. *Armillaria* in planted hosts. In: *Armillaria* Root Disease. Shaw, C.G., III and G.A. Kile. 1991. U.S.Dept. Agric. For. Serv. Agric. Handb. No. 691. 233p.

11. Klein-Gebbinck, H.W.; P.V. Blenis, and Hiratsuka, Y. 1990. Spread of *Armillaria ostoyae* in juvenile lodgepole pine stands in west central Alberta. Can. J. For. Res. 21: 20-24.

12. Morrison D.J. 1976. Vertical distribution of *Armillaria mellea* rhizomorphs in soil. Transactions of the British Mycological Society 66: 393-399.

13._____. 1981. *Armillaria* root disease. A guide to disease diagnosis, development and management in British Columbia. Environ. Can., Can. For. Serv. Info. Rep. BC-X-203 pp.1-16.

14. Morrison, D.J., H. Merler, and D. Norris 1991. Detection, recognition and management of *Armillaria* and *Phellinus* root diseases in the southern interior of British Columbia. B.C. Min. For., Res. Branch. FRDA Rep. No. 179 25p.

15. Nelson Forest Region, Standard Operating Procedures. Forest Health Manual. *Armillaria* Root Disease. 1994. (currently under review to ensure compatibility with FPC)

16. Pearce, M.H. and N. Malajczuk. 1990. Inoculation of Ecalyptus diversicolor thinning in stumps with wood decay fungi for control of *Armillaria luteobubalina*. Mycol. Res. 94 (1): 32:37.

17. Redfern, D.B. and G. M. Filip. 1991. Inoculum and infection. In: *Armillaria* Root Disease. Shaw, C.G. III and G.A. Kile. 1991. U.S.Dept. Agric. For. Serv., Agric. Handb. No. 691. 233p.

18. Reich, D.B. and J. Muir. 1991. Three-year spread of *Armillaria* root disease in a Cariboo Forest Region Douglas-fir plantation. Canadian Plant Disease Survey 71(1): 130.

19. Woods, A.J. 1994. The behavior and impacts of *Armillaria ostoyae* in mature stands and plantations in the Shuswap region of British Columbia. M. Sc. thesis. Univ. B. C. 119p.

20. Xiao, G. and B. Chapman. 1993. *Armillaria* Biocontrol.. Working plan. B.C. Min. For. Caribou Forest Region. 20p.

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